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# An Overview of a Flight Object Concept for the National Airspace System (NAS)

**September 2000**

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# Abstract

In an effort to accommodate predicted growth in air traffic, the Federal Aviation Administration (FAA) and the aviation community have developed a future concept of operations for the National Airspace System (NAS) called Free Flight. One of the underlying Free Flight concepts that requires further development is the "flight object," a concept for sharing common flight information elements among new and existing capabilities as the NAS evolves. Sharing common information elements improves the accuracy and availability of flight information updates, the consistency of flight planning in different Air Traffic Management (ATM) system domains and the transition of flights between domains, and enhances the availability of user preferences and recorded history information. This document and its accompanying web site incorporate feedback from FAA, The MITRE Corporation's Center for Advanced Aviation System Development (CAASD), and other cognizant personnel to describe the concept for the flight object and to identify issues that need to be examined before its implementation.

KEYWORDS: air traffic control, traffic flow management, flight object, information sharing, free flight, user preferences, intent, collaborative decision making, flight plan, trajectory

# Acknowledgments

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- Collaborative decision making for traffic flow management – Mary Yee
- Collaborative Routing Coordination Tools (CRCT) – Tony Chambliss
- Controller Pilot Data Link Communications (CPDLC) – Suzanne Bradley and Jerome Freedman
- Oceanic Air Traffic Control (ATC) – Lynne Hamrick and Mary Minnix
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- RTCA Surveillance Working Group, chartered by the Free Flight Select Committee – Nora Lawson
- Surface Management Advisor (SMA) and Datalink Delivery of Taxi Clearance (DDTC) – Jill Randlett
- Traffic Management Advisor (TMA) and Passive Final Approach Spacing Tool (pFAST) – John Lebron
- User Request Evaluation Tool (URET) – Al McFarland
- Weather tools – Jeff Mittelman

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- Information architecture – Katie Bolczak, Nels Broste, Ron Rhoades, and Ron Schwarz

- NAS flight data processing and architecture evolution – Al Cascone, Larry Deibel, and Elvan McMillen
- Traffic Flow Management (TFM) architecture and evolution – Pat Nussman and Tejal Topiwala
- Surveillance and flight intent – George Bartkiewicz, Ed Brestle, and Bob Geoghan

The feedback received from these CAASD personnel has shaped the content and direction of the work described in this document.

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**Section 1**

# Introduction

## 1.1 Background

The Federal Aviation Administration (FAA) manages and develops the National Airspace System (NAS) to support safe and efficient air traffic operations. To fulfill this responsibility, the FAA must research and analyze future air traffic projections of growth, as well as the ability of the NAS to handle those projections. This research and analysis helps the FAA gain insight into which procedural and automation improvements will be required to maintain NAS safety and efficiency as the traffic loads, patterns, and characteristics change. One key result of recent research and analysis has been the wide recognition that many NAS improvements are required to maintain safety and efficiency for the projected changes in traffic [1, 2, 3].

The FAA and the aviation community have developed a concept of operations called Free Flight to accommodate the predicted growth in air traffic while maintaining safety and efficiency in the NAS [4]. This Free Flight operational concept has been developed for the midterm time frame (nominally a period of time that centers around 2005) and builds on Free Flight Phase 1 (FFP1) capabilities that are scheduled for introduction by 2002 [5, 6], and Free Flight Phase 2 (FFP2) capabilities that are planned for introduction by 2005 [7]. The MITRE Corporation's Center for Advanced Aviation System Development (CAASD) is supporting the FAA in the development of the Free Flight operational concept and its implementation for FFP1 and FFP2.

One of the underlying Free Flight concepts that requires further development is the concept of the ***flight object***. The flight object is a collection of common information elements describing an individual flight and available electronically for use by both the NAS users and the ATM service providers. The flight object concept is based on sharing these common flight information elements among new and existing capabilities as the NAS evolves. Sharing common information elements improves the accuracy and availability of flight information updates, the consistency of flight planning in different Air Traffic Management (ATM) system domains and the transition of flights between domains, and enhances the availability of user preferences and recorded history information. This document and its accompanying web site [8] incorporate feedback from FAA, CAASD, and other cognizant personnel on future NAS capability, architecture, and evolution plans to describe the concept for the flight object. While this document provides background information, an overview of the concept, and a list of the issues that must be addressed before implementation, the web site provides more detailed information. Specifically, the web site examines the structure for organizing the discussion of flight information elements, the process for identifying flight information elements common to a set of capabilities, and the format for presenting flight object interactions with those capabilities. The concept is expected to evolve to reflect changing procedures, operational capabilities, and information architectures.

## 1.2 Purpose and Scope of this Document and the Accompanying Web Site

The purpose of this document is to provide an overview of the flight object concept and to describe how the accompanying web site can be used to explore the concept in more detail. Although this document does not provide a detailed concept for the flight object, it does provide the context for the flight object and an overview of its structure. The flight object is not a typical capability because it is not expected to be implemented as a separate operational capability; instead, it serves to provide a shared understanding of flight information among ATM service providers and NAS users, and their supporting capabilities. As such, the flight object concept is expected to be integrated into the operations and implementation of all the supporting capabilities and serves as the primary method for linking and sharing information in the NAS.

In this document and its accompanying web site, the flight object is described as an object in the object-oriented analysis sense (a design type of object rather than a software implementation type of object), providing a way to consider what is known about a flight and how it can be shared among decision support capabilities. The flight object description includes flight-specific elements for *descriptive* information such as the aircraft identifier and the origin and destination airports, and for *control-related* information such as the computer identifier and the controlling and receiving sectors. The flight object description does not include environment or weather information since these are system-wide elements that affect multiple flights. Although the flight object concept is described based on capabilities expected for implementation in the FFP1, FFP2, and beyond FFP2 time frames, the information elements that are listed as available through the flight object are only ***candidates*** for information to be shared by the capabilities in those time frames. The information elements that could actually be implemented as part of the flight object in the specified time frames are yet to be determined. Because the flight object information elements are expected to be available electronically for use by the Host Computer System (HCS, or Host) and by ATM capabilities, information that is expected to be known only to the controller or the pilot is not included.

## 1.3 Organization of this Document

Section 2 provides an overview of the future NAS environment and operational concepts. Section 3 provides an overview of the flight object concept for several time frames in an evolution towards the future environment and concepts described in Section 2. Information about exploring the accompanying web site to examine the flight object concept in more detail is provided in Section 4. Section 5 identifies issues for analysis and evaluation, and Section 6 provides a summary and some next steps.

## 1.4 Typographic Conventions

In this document, *components* of the flight object and the *categories* of information elements within them are shown in italics as follows: *component:category*.

Because the flight object concept described in this document is new, it requires much study and evaluation. In addition to describing the issues associated with the flight object in Section 5, gray issue boxes like the one below are placed in the concept overview section to associate the details of the flight object concept with individual issues. For the benefit of those reading this document electronically, internal document links to figures, tables, and other sections (including the List of References) are shown underlined and in color, as demonstrated with the link to Section 5 in the issue box below. Other links shown underlined and in color are links to web sites and e-mail notes that are external to this document; these links are noted as available online.

| Issue: Sample – Reference in Section 5 |
| --- |

Section 2

# Overview of the Future NAS Environment and Operational Concepts

This section presents an overview of the expected future environment and explains the rationale behind the future operational concepts. These concepts provide the necessary background for describing the flight object.

Each year, user demand for aviation services continues to grow. Historically, satisfying this demand has resulted in reliance on procedures and restrictions, such as structured airways, separation rules, and flow constraints. Today, NAS users have more information enabling them to make informed decisions that contribute to improved NAS management. Furthermore, users are demanding fewer delays and more routing and scheduling flexibility so they can operate more efficiently. Similarly, the FAA is responding to its own fiscal constraints by investigating ways to improve the efficiency of NAS operations. Due to financial realities, the NAS will have to accommodate future traffic increases with a more flexible service provider workforce. At the same time, maintaining or improving aviation safety is of paramount concern to both the FAA and the public. Consequently, new technologies and procedures are needed to accommodate increases in air traffic and improve safety.

New technologies and procedures will become available to support collaborative decision making between ATM service providers and NAS users as a primary feature of the future air traffic system. A collaborative environment gives NAS users greater operational flexibility and better access to NAS resources. It also provides better information for use by ATM service providers in workload management.

The future concepts have been developed with the goals of accommodating user preferences, handling increased traffic, and improving aviation safety. The concepts incorporate emerging technological advances and identify capabilities that will be used by the NAS users and the ATM service providers for collaborative decision making, and by the ATM service providers to better manage their workload.

The application of new technologies to support ***collaborative decision making*** between the NAS users and the ATM service providers results in new capabilities that support the following [9]:

- Reliable and timely information exchange and improved communication between ATM service providers and NAS users
- Improved understanding of NAS resource capacity and demand for those resources

- Detection and collaborative resolution of situations affecting traffic flows and NAS resource capacity
- Strategy evaluation to determine the impact of candidate traffic management actions on the NAS
- Improved measurement of NAS performance (both for real-time performance and for performance over time)

These capabilities require considerable development in infrastructure and automation, some of which is currently in progress.

Using new technologies to assist in ATM service provider ***workload management*** requires an understanding of the tasks performed by the ATM service providers, including those of tower, terminal, en route, oceanic, and traffic flow management ATM domains.[1] It is envisioned that most of the tasks performed today will also be performed in the future; however, the allocation of the tasks may differ [10]. In some cases, different service providers or decision support capabilities may perform one or many tasks. New technologies will also be available to assist flights as they navigate through the NAS.

Through the FAA's FFP1 and FFP2 programs, individual capabilities will be introduced that improve the accuracy of aircraft path (trajectory) predictions.[2] The deployment of these new decision support capabilities will improve the ATM service provider's ability to identify and resolve potential separation problems and traffic flow situations. Decision support capabilities will also help service providers determine whether user requests for flight plan changes will be problem-free. If a user request is predicted to have a problem, service providers can use decision support capabilities to automatically check that request periodically and notify the service provider as soon as the request is problem-free. Decision support capabilities will also include inter-sector and inter-facility automated coordination that will reduce the service provider workload associated with verbal communication. With the accumulated benefits of automated capabilities, service providers are available to provide Air Traffic Control (ATC) services to more aircraft.

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1 Today, controllers responsible for separating aircraft work in the tower, terminal, en route, and oceanic domains of the NAS. In addition to these controllers, the Traffic Management Coordinators (TMCs) at each Air Route Traffic Control Center (ARTCC, or Center) perform strategic planning tasks to ensure that the workload at the en route sectors remains manageable. The Traffic Management Specialists (TMSs) at the Air Traffic Control System Command Center (ATCSCC, or Command Center) perform longer-range strategic planning tasks involving more than one Center to manage situations and workload for those Centers.

2 Current plans for FFP1 and FFP2 programs do not address sharing improved trajectory predictions among capabilities.

As service providers increasingly take advantage of automated decision support capabilities, their job will likely evolve from one with tactical emphasis to a more strategic one. This longer range outlook should also be supported by improved trajectory estimation—and therefore improved strategic problem prediction—resulting from information downlinked from equipped aircraft [11]. It is anticipated that an improvement in problem prediction, a reduction of tactical problems, and an evolution toward a more strategic NAS will enable service providers to manage increases in traffic and possibly larger sectors. When sector workload is predicted to increase, impact on users is minimized by adjusting the NAS, through adjustments in airspace and/or sector staffing configurations, before implementing traffic planning strategies (for example, changing traffic flows). Because changes to flight plans, including those resulting from traffic planning strategies, affect NAS users, they should be implemented as necessary after NAS adjustments have been made.

With a capability to predict airspace traffic density, sector configurations can be adjusted to balance air traffic among neighboring sectors, avoiding unnecessary modifications to traffic flows. Although a dynamically reconfigurable airspace to support these options would be desirable, some constraints may exist (such as service provider training and the equipment associated with particular Centers). These constraints may limit the ability to change sector configurations.

Shifting service provider roles to more strategic ones and enabling service providers to dynamically adjust sector configurations should be accomplished in an evolutionary manner. Thus, the operational concepts, and specifically, the roles and responsibilities of the service providers, need to be defined in easy-to-implement steps so that procedures and capabilities build upon one another. Ongoing research explores the capabilities needed to support activities in the ATM domains, to determine the applicability of previously developed capabilities to meet those needs, and to postulate new types of capabilities. As this research progresses, the operational concept documents will need to be updated to reflect the research findings.

**Section 3**
# Overview of the Flight Object Concept

As the NAS evolves towards the future concepts described in Section 2, new capabilities in the form of automation and procedures will be introduced to support ATM service providers in the different domains of the NAS. In addition to assisting the service providers in better managing their workload, these capabilities will support collaboration with NAS users. Many of these capabilities will use various types of information associated with flights in the NAS, and as a result, they are likely to operate using some of the same information elements.

A ***flight object***, defined as a collection of common information elements describing an individual flight and available electronically for use by both the NAS users and the ATM service providers, can be introduced to facilitate the sharing of common flight information elements among the various capabilities. Sharing common information elements using the flight object has a number of potential advantages:

- Improved accuracy and availability of flight information updates
- Improved consistency of flight planning in different domains and a smoother transition of flights between domains
- Enhanced availability of user preferences for real-time planning and recorded history information for post-analysis processing
- Improved effectiveness of ongoing traffic management initiatives and the associated collaborative decision-making process
- Enhanced ability of service provider to issue traffic advisories to controlled aircraft about uncontrolled aircraft and to provide flight following services for aircraft flying Visual Flight Rules (VFR)

Implementation of a flight object concept like the one proposed in this document and the accompanying web site could potentially have these types of advantages for the NAS users and ATM service providers. The flight object concept describes the structure for organizing the discussion of flight information elements, the process for identifying flight information elements common to a set of capabilities, and the format for presenting flight object interactions with those capabilities. In this concept, the flight object is considered the set of information elements common to the capabilities available in a specific time frame; the actual implementation of the flight object as part of the NAS is beyond the scope of this document.

Issues:

Collaboration Among ATM Service Providers and NAS Users – Section 5.1.1

Roles and Responsibilities for Collaboration Among ATM Service Providers and NAS Users – Section 5.1.2

Types of Information to Support Collaboration Among ATM Service Providers and NAS Users – Section 5.1.3

Performance Metrics to Evaluate Collaboration Among ATM Service Providers and NAS Users – Section 5.1.4

Although this document does not provide a detailed concept for the flight object, it does provide the context for the flight object and an overview of its structure. This section provides an overview of the flight object concept based on the capabilities expected for implementation in three different time frames: the FFP1 time frame, the FFP2 time frame, and the beyond FFP2 time frame. For each time frame, the information elements common to capabilities available in that time frame are ***candidates*** for including in the flight object and sharing with other capabilities. The information elements that could actually be implemented as part of the flight object in the specified time frames are yet to be determined. Many issues about the architecture and implementation of the flight object remain. In the FFP1 and FFP2 time frames, it is expected that the Host's flight information will be available outside of the flight object, through a direct connection with the ATM capabilities. It is not until the beyond FFP2 time frame that the Host's flight information is expected to be available through an implementation of the flight object.

Issues:

Architecture for the Flight Object – Section 5.5.2

Implementation of the Flight Object – Section 5.5.3

Transition to the Flight Object – Section 5.5.4

Availability of Host Flight Information through the Flight Object – Section 5.5.1

Further details about the flight object concept can be found in the web site accompanying this document [8]. See Section 4 of this document for more information about accessing the web site.

## 3.1 Flight Object Organization

As shown in Figure 3-1, the flight object has the following three major components:

- The ***flight as filed*** portion of the flight object contains information from NAS user personnel and capabilities. This portion of the flight object could extend beyond today's filed flight plan to include flight intent and user preferences.
- The ***flight as cleared*** portion of the flight object contains information from ATM service providers and capabilities, such as clearances and possible flight plan amendments.
- The ***flight as flown*** portion of the flight object contains information from sensors and pilot reports, including position reports and reported flight conditions.

The types of information elements within each of these major components of the flight object can be categorized as historical information, current information, or planned or projected information [Available online: View flight object organization on web site]. In this document, the nomenclature used to denote one of these categories within a major component of the flight object structure is *component:category* (for example, *flight as flown:current*). Because the flight-specific information elements associated with the capabilities fit well into this structure, it is the nomenclature used to discuss the concept for sharing flight information among current and future ATM capabilities.

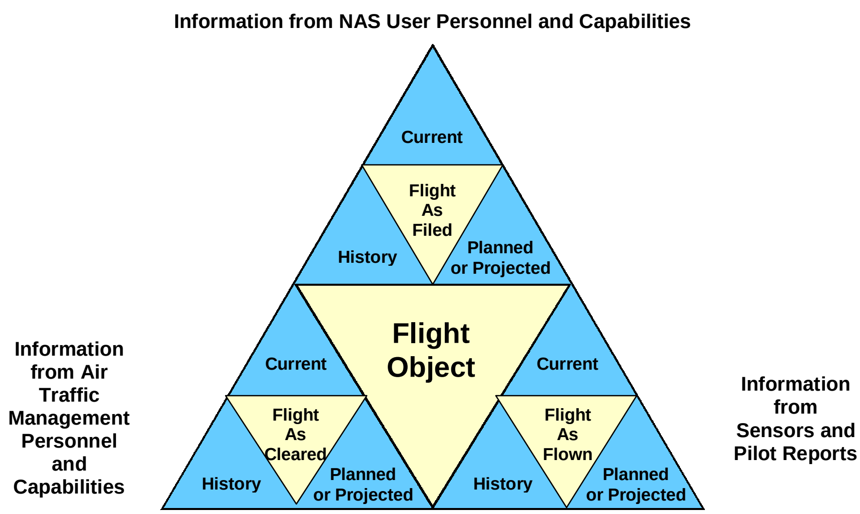


**Figure 3-1. Flight Object Organization**

Issues:

Subset of Flight Information Elements from the Host – Section 5.3.1

Levels of Accuracy Required for Information Elements – Section 5.3.2

Incorporation of Advisories into the Flight Object – Section 5.3.3

Use of Intent, Environment, and Weather Information in the Flight Object – Section 5.3.4

The information described by the flight object is dynamic and varies depending on the status of the flight [Available online: View flight object dynamics]. For any particular flight, the scheduled flight plan information (like that available for scheduled flight plans stored in bulk) is available in the *flight as filed:planned or projected* portion of the flight object. As flight plans are filed and flights are flown, the corresponding flight plan information propagates through the different portions of the flight object as follows:

- When the user files the flight plan for a flight, the flight plan becomes current and is available in the *flight as filed:current* portion of the flight object.
- When the system accepts the filed flight plan, it becomes available in the *flight as cleared:planned or projected* portion of the flight object.
- When the flight departs as cleared, the flight plan is activated and becomes available in the *flight as cleared:current* portion of the flight plan.

This flight plan is then archived to the *flight as cleared:history* portion of the flight object when it has been amended or when the flight lands.

Issues:

Differences Between Today's Flight Path Representations – Section 5.4.1

Trajectory Components – Section 5.4.2

Flight Activation Event – Section 5.4.3

Common Trajectory Representation – Section 5.4.4

## 3.2 Planned Capabilities

The capabilities planned for implementation in the ***FFP1 time frame*** [5, 6] are listed below:

- Surface Movement Advisor (SMA)
- Passive Final Approach Spacing Tool (pFAST)
- User Request Evaluation Tool (URET) Core Capability Limited Deployment (CCLD)
- Traffic Management Advisor-Single Center (TMA-SC)
- Collaborative Decision Making (CDM) – Flight Schedule Monitor (FSM)
- Data Link (oceanic) –
  - Controller Pilot Data Link Communications (CPDLC)
  - Automatic Dependent Surveillance - Addressable (ADS-A)
- Enhanced oceanic capabilities

Because many of these capabilities are being implemented using a spiral development process (first introducing core capabilities with limited deployment and then enhancing those capabilities in a wider deployment), they are likely to be available at only a few facilities when they are first introduced.

In the ***FFP2 time frame***, increased availability of the FFP1 capabilities is expected [7], along with the introduction of the following new and enhanced capabilities:

- Enhanced SMA
- Enhanced URET
- CDM – Collaborative Routing Coordination Tools (CRCT)
- Data Link (domestic) – CPDLC
- High Altitude Services (HAS)

A summary of the planned capabilities to be introduced in the FFP1 and FFP2 time frames is shown in Figure 3-2, as allocated to the different ATM domains within the NAS (the "flight" domain contains cross-cutting capabilities such as air-ground communications, or data link) [Available online: View planned capabilities].

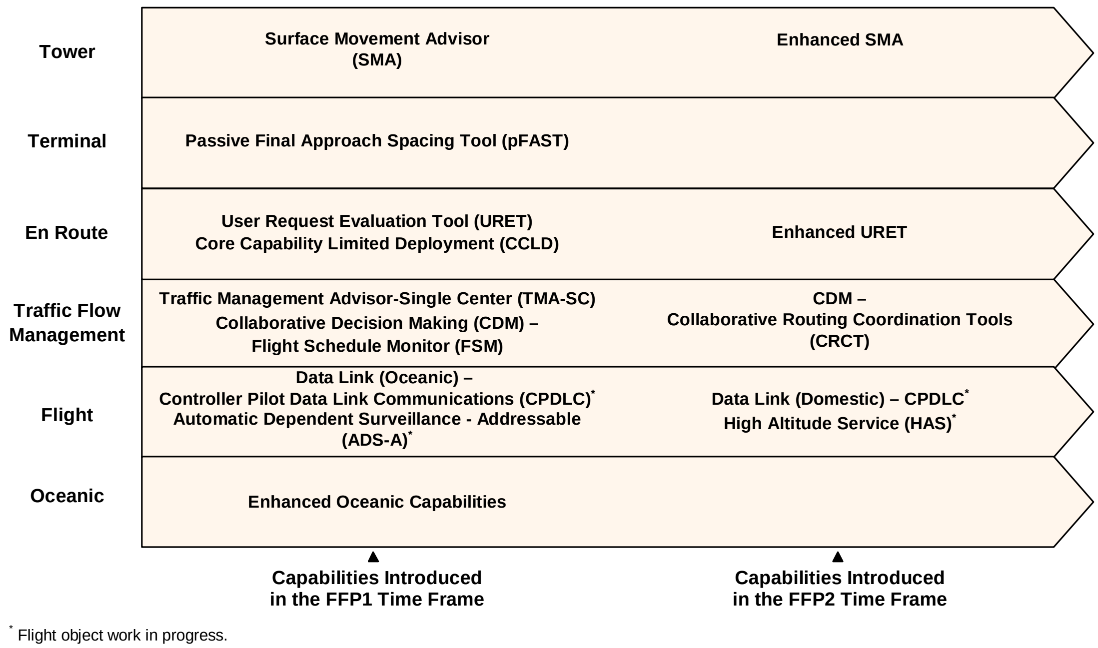


**Figure 3-2. Planned Capabilities to be Introduced in the FFP1 and FFP2 Time Frames**

In addition to the capabilities introduced in the FFP1 and FFP2 time frames, the following capabilities are planned for the ***beyond FFP2 time frame***:

- Surface Management System (SMS) in the tower domain, which may include SMA enhancements and Datalink Delivery of Taxi Clearance (DDTC)
- Expansion of flight data processing capabilities beyond the en route domain into other ATM domains within the NAS
- Additional URET enhancements to include automatically initiated problem resolution in the en route domain (manually initiated problem resolution may be available in the FFP2 time frame)
- Enhancements to Traffic Flow Management (TFM) capabilities, including Multi-Center Traffic Management Advisor (McTMA), as well as additional collaborative decision making capabilities and post-analysis capabilities, such as the following:
  - Integrated Impact Tool (IIT) – integrates one-dimensional impact results from CRCT, FSM, and other capabilities

- Post Operative Evaluation Tool (POET) – compares filed or planned flight information to actual flight information based on Enhanced Traffic Management System (ETMS) data and carrier-supplied information

- Data Link – Automatic Dependent Surveillance - Broadcast (ADS-B) in the flight domain

It is expected that the flight object will eventually interface with all capabilities that can take advantage of shared flight information. In addition to the ATM capabilities listed above, capabilities that may benefit from shared flight information include the following:

- User flight planning and performance analysis capabilities
- Search and rescue capabilities
- Accident investigation capabilities
- Flight Service Stations (FSSs)
- ETMS
- Sector suite staffing and scheduling capabilities
- Air Traffic Control System Command Center (ATCSCC, or Command Center) capabilities
- All en route Air Route Traffic Control Center (ARTCC, or Center) capabilities
- Terminal Radar Approach Control Facility (TRACON) capabilities

It is possible that these additional capabilities will be available in the beyond FFP2 time frame, but because they are not yet well defined, they have not been fully incorporated into this concept.

Issue: Planned Capabilities – Section 5.2

## 3.3 Shared Information Elements

For each of the capabilities in the FFP1 and FFP2 time frames, the information elements that those capabilities could *use* from the flight object or *provide* to the flight object have been identified.[3] These information elements have been allocated to the different components of the flight object shown in Figure 3-1, and are described in more detail in the web site.

After identifying all of the information elements that could potentially be shared by the capabilities in the FFP1 and FFP2 time frames, the elements that are accessed by more than one capability have been identified as candidates to be shared for each time frame. A summary of the candidate information elements that could be part of the flight object in these time frames is shown in Table 3-1 and on the web site [Available online: View FFP1/FFP2 shared elements].

Additional information elements that could be shared in the beyond FFP2 time frame include the following:

- Discrete identification code that provides precise location and identity information
- All necessary information to initiate search and rescue for VFR flights
- Flight profile to replace today's flight plan (user's preferred flight path or more detailed time-based flight trajectory)
- Information to support flight planning
- Internationally coordinated trajectory
- Information to improve trajectory modeling
  - Departure information, including more accurate actual departure times and takeoff weights
  - En route information
    - Improved information describing controller intent (for example, vector maneuvers and speed adjustments)
    - Flight intent and user preferences [12] (for example, user constraints that drive filed flight intent; user flight intent as if flight were to be unconstrained, such as planned turn, speed, and speed gradient profiles; and user preferences for handling flight constraints, such as severe weather areas)
    - Improved aircraft performance data
    - Knowledge of aircraft weight

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3 The information elements identified for the data link capabilities do not include the content of the data link exchanges.

**Table 3-1. Flight Object Information Element Candidates for the FFP1 and FFP2 Time Frames**

| Flight Object Component | Information Elements for the FFP1 Time Frame | Information Elements for the FFP2 Time Frame |
|---|---|---|
| *Flight as filed* | Aircraft identifier and type<br>Equipment in use<br>Unique equipment-specific data link address<br>Origin and destination airports<br>Scheduled departure time | Aircraft identifier and type<br>Equipment in use<br>Unique equipment-specific data link address<br>Origin and destination airports<br>Filed route, cruise altitude, and cruise speed<br>Scheduled and proposed departure times |
| *Flight as cleared* | Computer identifier<br>Route, altitude, and speed<br>Controlling and receiving sectors<br>Required frequency and type of ADS-A reports<br>Data link messages (coordination and clearances)<br>Delay needed<br>Predicted separation problems and trial plans | Computer identifier and transponder code<br>Route, altitude, and speed<br>Estimated time at downstream fixes<br>Controlling and receiving sectors<br>Required frequency and type of ADS-A reports<br>Data link messages (coordination and clearances)<br>Delay needed and Traffic Management Advisor (TMA)-scheduled time at fix<br>Predicted separation problems and trial plans<br>Proposed TFM reroute<br>Coordination estimates<br>Landing runway |
| *Flight as flown* | Radar track position<br>Calculated speed and direction<br>Position and altitude reports<br>Data link messages (position, wind, and weather) | Actual departure time<br>Radar track position<br>Calculated speed and direction<br>Position and altitude reports<br>Data link messages (position, wind, and weather)<br>Estimated Time of Arrival (TOA) at runway |

- Information to improve trajectory modeling (concluded)
  - TFM information
    - Improved information describing controller intent (for example, vector maneuvers and speed)
    - Flight intent and user preferences

Other types of information that capabilities might benefit from sharing, such as environment and weather information, are beyond the scope of this document.

Issues:

Shared Information Elements – Section 5.3.5

Use of Intent, Environment, and Weather Information in the Flight Object – Section 5.3.4

## 3.4 Time of Availability

The view of the flight object from the *time of availability* perspective describes a relationship between the flight object information elements and the future capabilities that will need to access them during different periods of time throughout the life cycle of a flight. This view of the flight object will be useful in developing performance and sizing requirements for its implementation, including the requirements for the individual capabilities that will use information from or provide information to the flight object.

A high-level view of the flight object from the time of availability perspective in the beyond FFP2 time frame is illustrated on the web site [Available online: View time of availability]. This view indicates how long the information elements would need to be available by listing the information elements that need to be accessed during different pre- and post-departure time periods, as follows:

- Accessible less than 90 days prior to departure
- Accessible less than 24 hours prior to departure
- Accessible while the flight is active
- Accessible after the flight is terminated

This view also indicates how quickly the information elements would need to be accessed by the capabilities during those time periods, as follows:

- Accessible within seconds
- Accessible within minutes
- Accessible within hours

These types of information take a first step towards defining the performance and sizing requirements for implementation of the flight object.

| Issues: |
| --- |
| Architecture for the Flight Object – Section 5.5.2 |
| Implementation of the Flight Object – Section 5.5.3 |
| Transition to the Flight Object – Section 5.5.4 |
| Availability of Host Flight Information through the Flight Object – Section 5.5.1 |

## 3.5 Flight Object Interactions

The flight object interactions shown in the interactions section of the web site [Available online: View interactions] describe how personnel and capabilities (Figure 3-1) interact with each component of the flight object in the FFP1 time frame.[4] Summaries of the interactions show how personnel and capabilities interact with the flight object to use and provide information from the three flight object components. For example, the interaction summary for the *flight as filed* component shows how users file and update flight plans.

More detail is provided for each component of the flight object by showing the actions and the information elements associated with creating, updating, and archiving the flight object. These views are useful for identifying which personnel and capabilities use or provide different types of flight object information. As an example, users create the flight object for a specific flight by submitting different sets of information elements that are associated with scheduled flight plans or published Official Airline Guide (OAG) entries.

4 The information elements that an individual capability uses or provides are shown in the planned capability section of the web site (see Section 3.2).

Section 4

# Web Site to Coordinate the Flight Object Concept

The flight object web site referenced in Section 3 has been developed to facilitate the coordination and understanding of the flight object concept within the FAA and CAASD, as well as with other organizations such as NAS users. This web site contains more detail about the types of information provided in Section 3, and has been designed to facilitate access to supporting detail and documentation, as well as electronic feedback from those who view the web site. This section provides an overview of the web site, including how to access it, how to navigate through it, and how to provide feedback to the FAA so the flight object concept can be updated.

## 4.1 Accessing the Web Site

The web site is available online at the following URL (Uniform Resource Locator):

http://www.caasd.org/flight_object_concept/index.htm

Please report any problems accessing this web site to Steve Bradford of the Office of System Architecture and Investment Analysis (ASD) at the FAA using the following e-mail address available online: Steve.Bradford@faa.gov.

## 4.2 Navigating through the Web Site

After gaining access to the web site, you can navigate through it to view more details about the flight object concept and to provide feedback electronically. The structure of the site is shown in Figure 4-1 and briefly described below.

On each page within the web site, you can access the top-level view of the ***Home***, ***Overview***, or ***Contents*** portions of the site using the navigation buttons at the bottom of the page. ***Home*** contains our mission and additional source information, ***Overview*** contains a list of flight object topics that are discussed in more detail, and ***Contents*** provides a table of contents for the web site pages.

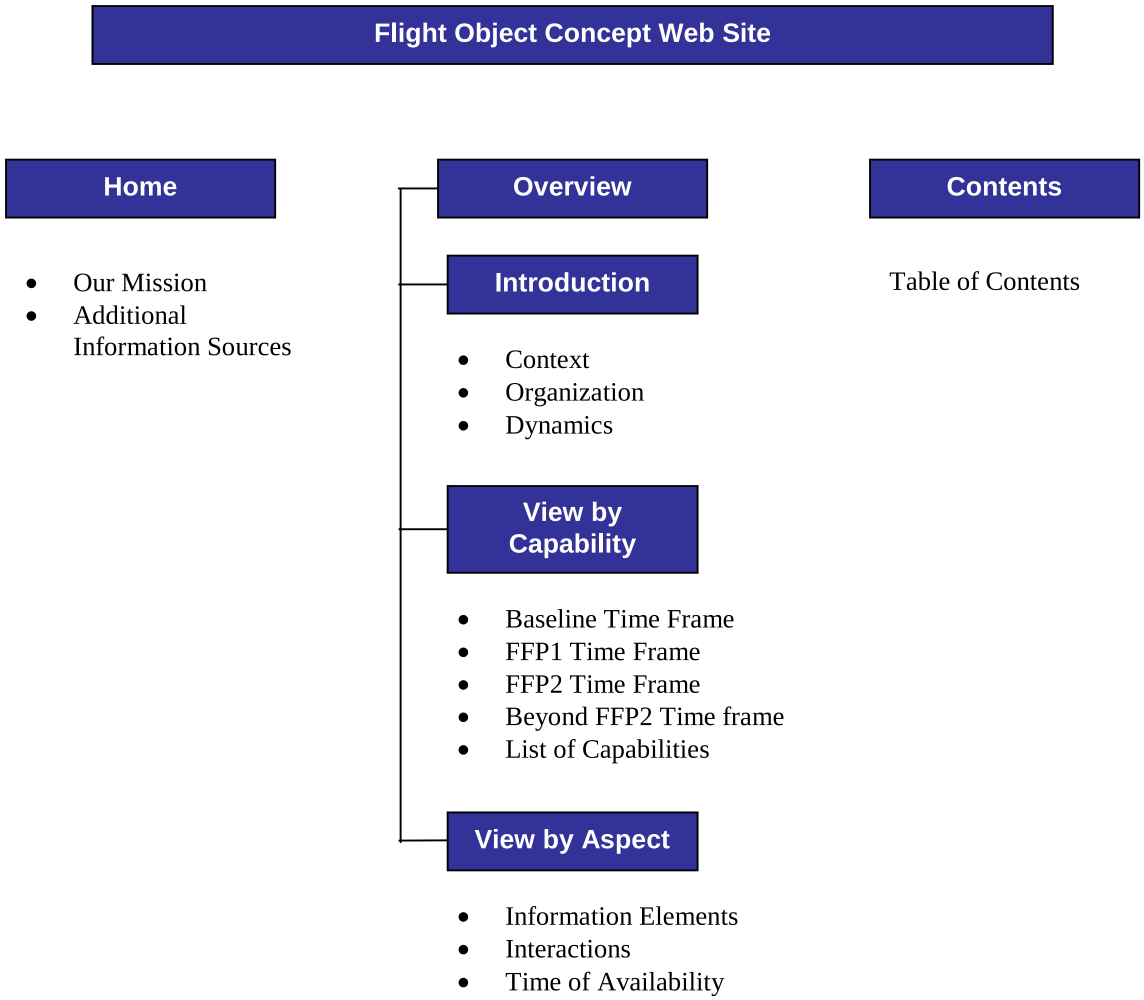


**Figure 4-1. Structure of Flight Object Concept Web Site**

Within the ***Overview*** portion of the web site, the ***Introduction*** describes the context of this project work, along with the organization of the flight object and an example of flight object dynamics. Within ***View by Capability***, you can view the capabilities that are planned to be introduced in each of the designated time frames (baseline, FFP1, FFP2, and beyond FFP2 time frames). Within ***View by Aspect***, you can view a list of all information elements and the summary of the candidate information elements to be shared among capabilities within the FFP1 and FFP2 time frames. In addition, the ***View by Aspect*** portion includes the interactions with the flight object and the information associated with the time of availability perspective.

## 4.3 Providing Feedback

If you would like to provide feedback to the FAA on the contents of the site, you can use the feedback link on the site (located at the bottom of each page), or contact Steve Bradford of ASD-130 at the following e-mail address available online: Steve.Bradford@faa.gov.

Section 5

# Issues for Analysis and Evaluation

The flight object concept described in this document and the accompanying web site raises a number of issues. This section describes those issues, along with recommendations for resolving them. All issues should be addressed before the flight object can be implemented in an operational environment.

## 5.1 Collaboration Issues

### 5.1.1 Collaboration Among ATM Service Providers and NAS Users

**Issue:** How can the ATM service providers collaborate with the NAS users to share flight object information?

**Recommendation:** Identify the types of flight information that both the ATM service providers and the NAS users could benefit from sharing, such as service provider and user intent (see also Section 5.3.4). Examine how information sharing can affect the decision-making processes for both the ATM service providers and the NAS users. Evaluate the usefulness of different methods for sharing flight information.

### 5.1.2 Roles and Responsibilities for Collaboration Among ATM Service Providers and NAS Users

**Issue:** What are the roles and responsibilities for the ATM services providers and the NAS users in sharing flight object information?

**Recommendation:** Identify the source(s) of the different types of information elements to be shared and determine the needs for those types of information elements. Evaluate different possible assignments of roles and responsibilities for creating, updating, and archiving the shared information elements to determine the most efficient assignment of roles and responsibilities for sharing the information among ATM service providers and NAS users.

### 5.1.3 Types of Information to Support Collaboration Among ATM Service Providers and NAS Users

**Issue:** What types of information elements are needed to support collaboration among ATM service providers and NAS users?

**Recommendation:** Identify the different types of information elements that may be useful in collaborating among ATM service providers and NAS users. Examine the costs and benefits associated with sharing the different types of information elements to determine which types of information elements are most useful for collaboration.

### 5.1.4 Performance Metrics to Evaluate Collaboration Among ATM Service Providers and NAS Users

**Issue:** What types of performance metrics are needed to evaluate collaboration among ATM service providers and NAS users?

**Recommendation:** Identify the goals to be accomplished through collaboration among the ATM service providers and NAS users. Explore various available performance metrics to determine which metrics best support the evaluation of collaboration and the determination of how well the stated goals are met.

## 5.2 Planned Capability Issue

**Issue:** Some of the FFP2 capabilities identified in this paper have not yet been well defined (such as High Altitude Services, or HAS). How will these capabilities change as they become more defined, and how will the entire set of planned capabilities evolve for the FFP1 and FFP2 time frames? Which capabilities are planned for the beyond FFP2 time frame? How will new capabilities, as well as existing capabilities that evolve over time, interact with the flight object as it evolves to the concept described in this paper?

**Recommendation:** Periodically reassess the capabilities planned for the FFP1, FFP2, and beyond FFP2 time frames to determine whether the planned set of capabilities has changed and how the definitions of the planned capabilities have evolved. Update the flight object concept in response to changes in the planned capabilities, as well as changes in the concept itself.

## 5.3 General Information Element Issues

### 5.3.1 Subset of Flight Information Elements from the Host

**Issue:** For this document and its accompanying web site, a subset of the flight information elements available in the Host was chosen. The information elements in this subset are applicable to the planned capabilities that have been identified for the FFP1 and FFP2 time frames. How will these Host information elements change as the planned capabilities for the FFP1, FFP2, and beyond FFP2 time frames evolve?

**Recommendation:** Periodically reassess the capabilities planned for the FFP1, FFP2, and beyond FFP2 time frames to determine whether the subset of flight information elements available from the Host has changed as the planned capabilities has evolved. Update the flight object concept accordingly.

### 5.3.2 Levels of Accuracy Required for Information Elements

**Issue:** What level(s) of accuracy should be available through the flight object for an information element that is used with different levels of accuracy by different capabilities (such as current speed or heading)? Should the flight object make that information element available with the different levels of accuracy, or should the flight object make the element available with the highest level of accuracy?

**Recommendation:** Determine the level of accuracy required by each capability that uses each common information element. In cases where different levels of accuracy are required for the same information element, evaluate the costs and benefits of using that element with the highest level of accuracy in each of the shared capabilities. Determine whether each information element needs to be available with several levels of accuracy, evaluating the associated costs for maintaining more than one representation of the same information element within the flight object. Develop standards for information elements as appropriate.

### 5.3.3 Incorporation of Advisories into the Flight Object

**Issue:** How should an advisory (such as a TMA metering assignment or a pFAST landing assignment) be incorporated into the flight object? How do these advisories differ from constraints?

**Recommendation:** Evaluate the options for incorporating an advisory into the flight object. Determine whether an advisory such as a TMA metering assignment should be included in the *flight as cleared:planned* portion of the flight object as a TFM-requested action, or as part of the "expected to be cleared" trajectory. Also determine when the advisory would be available as part of the *flight as cleared:current* portion of the flight object. For example, an advisory can either be incorporated into the current flight plan after it has been shown to the service provider, or after the service provider has amended the flight plan to include the metering assignment.

### 5.3.4 Use of Intent, Environment, and Weather Information in the Flight Object

**Issue:** This document and the accompanying web site include descriptive and control-related information elements for flights. What other types of information should be shared as part of the flight object? Although it is generally agreed that intent (both service provider and user intent) is likely to be quite useful, what types of information describe intent and how could they be used by the ATM capabilities? Would it also be useful to include environment and weather information in the flight object?

**Recommendation:** Identify the types of intent information that NAS users provide for ATM service providers, the types of intent information that service providers need to resolve potential separation problems and traffic flow situations, and then the useful types of intent information that are not yet available to service providers. Determine the steps that are necessary to make the needed types of information available to service providers. In addition, examine the usefulness of including service provider intent, environment, and weather information as part of a shared flight object.

### 5.3.5 Shared Information Elements

**Issue:** How will the set of information elements that could be shared for the capabilities expected to become available in the FFP1 and FFP2 time frames change as the planned capabilities for these time frames evolve and become more defined? Which new information elements could be shared for the capabilities expected to become available in the beyond FFP2 time frame?

**Recommendation:** Periodically reassess the capabilities planned for the FFP1, FFP2, and beyond FFP2 time frames to determine whether the set of shared information elements has changed as the planned capabilities evolve and become more defined. Update the flight object concept accordingly.

## 5.4 Trajectory Issues

### 5.4.1 Differences Between Today's Flight Path Representations

**Issue:** The flight path representations used today by the Host and other ATM capabilities differ. The Host uses a flight's converted route as cleared, along with the currently cleared altitude, for posting flight progress strips, distributing flight information, and checking track association. When a flight is not found to be where it is expected, the Host's flight path representation is not updated. Other ATM capabilities, such as URET CCLD, use a four-dimensional trajectory as it is expected to be cleared for problem prediction and trial planning. When a flight is not found to be where it is expected, the other ATM capabilities reconform the trajectory to incorporate the most recent position information.

Given the future plan for the Host to integrate its current representation of past track with a four-dimensional trajectory for the flight path projection, how will the ATM capabilities be affected? (See also Section 5.4.4.)

**Recommendation:** Identify a type of flight path representation, such as a version of the four-dimensional trajectory, that provides the information necessary to support Host processing and the ATM capabilities. Determine how the Host and the ATM capabilities could evolve to incorporate this type of flight path representation and identify the resulting effects on the ATM capabilities.

### 5.4.2 Trajectory Components

**Issue:** What types of information are considered part of a trajectory? It is widely accepted that a trajectory should contain a string of four-dimensional points that describe the future path for a flight. Should a trajectory also include service provider or flight intent, such as avoiding a Special Use Airspace (SUA) or climbing out of turbulent airspace? Should a trajectory include predicted separation problems and resolutions associated with that flight?

**Recommendation:** Evaluate the cost and the benefits associated with including additional types of information, such as intent or predicted problems, in a trajectory. Determine which additional types of information would be appropriate for including in a shared trajectory.

### 5.4.3 Flight Activation Event

**Issue:** Which flight activation event should initiate that flight's representation in the *flight as cleared:current* portion of the flight object? In the FFP1 and FFP2 time frames, a flight will be considered activated when the Host receives the departure message for that flight. In the beyond FFP2 time frame, should the flight be considered activated when the pre-departure clearance is given?

**Recommendation:** Identify the system requirements for using the pre-departure clearance for flight activation, as well as the potential effects of the resulting changes for the capabilities sharing information through the flight object. Evaluate the cost and benefits for activating a flight (making the flight plan available in the *flight as cleared:current* portion of the flight object) when the pre-departure clearance is given.

### 5.4.4 Common Trajectory Representation

**Issue:** A trajectory is the calculated prediction of an aircraft's path based on a current or proposed flight plan, weather information, aircraft and flight characteristics data, and other variables (such as Standard Operating Procedures, or SOPs, and Letters of Agreement, or LOAs, which are imposed on flights but are unknown to the NAS users). Both URET CCLD and TMA from the Center-TRACON Automation System (CTAS) perform strategic operations using trajectories for active flights in their airspace. Table 5-1 describes a high-level comparison of the FFP1 trajectories that are used by URET CCLD and TMA.

Would the individual capabilities and the system as a whole benefit from sharing a common trajectory? If so, which elements of a trajectory should be shared among the capabilities accessing the flight object? Should shared elements simply have a common representation (and accuracy level), or should they be derived using a common algorithm as well?

**Recommendation:** Evaluate the following options to determine which option best serves the individual capabilities and the system as a whole.

- Provide a common trajectory to be used by all capabilities (a common representation or also derived using a common algorithm).

- Retain capability-specific trajectories, making them available to all other capabilities.
- Retain capability-specific trajectories, creating them from flight information elements that are available to all of the capabilities.
- Retain capability-specific trajectories, sharing only the necessary coordination information with other capabilities (for example, URET could provide estimated fix arrival times to TMA and TMA could provide assigned meter fix arrival times back to URET).

**Table 5-1. Comparison of FFP1 Application-Specific Trajectories** [13]

| Trajectory Characteristics | URET CCLD-Specific Trajectory | CTAS-Specific Trajectory (for TMA) |
|---|---|---|
| Route processing | Emulates Host (independent) for route conversion | Directly uses the Host's converted route from the Aircraft Route Record Table (AK) |
| Climb and descent profiles | Looks up rate as a function of aircraft type and weight for a nominal speed | Computes rate and acceleration as a function of aircraft type, weight, and speed |
| Data source for internal flights | Uses Host flight plan route, track position/velocity, and mode-C altitude | Uses Host flight plan route, track position/velocity, and mode-C altitude |
| Data source for external flights | Track data from Host computers at other sites running URET CCLD | ETMS data |
| Trajectory provided | Four-dimensional trajectory prediction (piecewise continuous set of linearly-varying segments) | Four-dimensional trajectory prediction (piecewise continuous set of linearly-varying segments) |

## 5.5 Technical Issues

### 5.5.1 Availability of Host Flight Information through the Flight Object

**Issue:** When can the Host's flight information become available through an implementation of the flight object? In the FFP1 and FFP2 time frames, it is expected that the Host's flight information will be available outside of the flight object, through a direct connection with the ATM capabilities. In the beyond FFP2 time frame, can the Host's flight information be available through an implementation of the flight object?

**Recommendation:** Identify the requirements for making the Host's flight information available through an implementation of the flight object, as well as the potential effects of the resulting changes on the capabilities sharing information through the flight object. Evaluate the cost and benefits of making the Host's flight information available through an implementation of the flight object.

### 5.5.2 Architecture for the Flight Object

**Issue:** What is the most efficient network, hardware, and software architecture for sharing flight object information elements?

**Recommendation:** Examine various architectures (from centralized to decentralized) to determine most robust architecture for maintaining and distributing flight object information elements.

### 5.5.3 Implementation of the Flight Object

**Issue:** What is the best alternative for providing flight object information to multiple locations (hardware and software alternatives)?

**Recommendation:** Examine hardware and software alternatives for implementing the chosen flight object architecture to determine how the flight object can be most efficiently implemented with the required reliability, availability, maintainability, and other important system characteristics.

### 5.5.4 Transition to the Flight Object

**Issue:** What is the best strategy for transitioning to the new flight object concept, e.g., are there interim steps that make sense?

**Recommendation:** Identify possible strategies comprised by interim steps that transition from today's use of flight information to the new flight object concept. Develop a plan to examine these strategies both analytically and in laboratory exercises. Evaluate the strategies using pertinent performance metrics to choose a feasible strategy that will enable early benefits to users and service providers, as well as sensible interim steps towards implementation of the complete flight object concept.

Section 6

# Summary and Next Steps

The flight object concept in this document and the accompanying web site describes the organization used to categorize flight object information elements, the planned capabilities for three future time frames, the candidates for shared information elements in the nearer time frames, the time of availability view of the flight object in the furthest time frame, and the various interactions with the flight object. This document provides an overview of the flight object concept (Section 3), and the accompanying web site described in Section 4 provides more details for that concept. Issues that need to be addressed are correlated with the flight object concept and are described in more detail with their appropriate recommendations in Section 5.

An important next step is to make the flight object information in this document and the accompanying web site available throughout the FAA and MITRE/CAASD, as well as to the NAS users, for facilitating the discussion of candidate flight object information elements and the flight object concept. As the flight object discussion continues, revisions to this document and its accompanying web site are planned, documenting results of ongoing research (such as the development and application of a common trajectory) and any additional issues that require analysis and evaluation before information elements can actually be shared within the NAS. Examination of the issues associated with the flight object will provide more information to support the development of Host and ATM capability requirements.

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# Glossary

**ADS-A** Automatic Dependent Surveillance - Addressable
**ADS-B** Automatic Dependent Surveillance - Broadcast
**AK** Aircraft Route Record Table
**ARTCC** Air Route Traffic Control Center
**ASQP** Airline Service Quality Performance
**ATC** Air Traffic Control
**ATCSCC** Air Traffic Control System Command Center
**ATM** Air Traffic Management

**CAASD** Center for Advanced Aviation System Development
**CCLD** Core Capability Limited Deployment
**CDM** Collaborative Decision Making
**CNS** Communication, Navigation, and Surveillance
**CPDLC** Controller Pilot Data Link Communications
**CRCT** Collaborative Routing Coordination Tools
**CTAS** Center-TRACON Automation System

**DDTC** Datalink Delivery of Taxi Clearance

**ETMS** Enhanced Traffic Management System

**FAA** Federal Aviation Administration
**FFP1** Free Flight Phase 1
**FFP2** Free Flight Phase 2
**FSM** Flight Schedule Monitor
**FSS** Flight Service Station
**FY** Fiscal Year

**HAS** High Altitude Services
**HCS** Host Computer System

**IIT** Integrated Impact Tool

**LOA** Letter of Agreement

**McTMA** Multi-Center Traffic Management Advisor
**MIT** Massachusetts Institute of Technology

**NAS** National Airspace System

**OAG** Official Airline Guide
**OOOI** Out, Off, On, In (*aka* ASQP data)

**PFAST** Passive Final Approach Spacing Tool
**POET** Post Operative Evaluation Tool

**R&D** Research and Development

**SMA** Surface Management Advisor
**SMS** Surface Management System
**SOP** Standard Operating Procedure
**SUA** Special Use Airspace

**TFM** Traffic Flow Management
**TJM** Trajectory Modeling
**TMA** Traffic Management Advisor
**TMA-SC** Traffic Management Advisor-Single Center
**TMC** Traffic Management Coordinator

| | |
|---|---|
| **TMS** | Traffic Management Specialist |
| **TOA** | Time of Arrival |
| **TRACON** | Terminal Radar Approach Control |
| **URET** | User Request Evaluation Tool |
| **URL** | Uniform Resource Locator |
| **VFR** | Visual Flight Rules |